

SYSTEM AND APPARATUS FOR TESTING PACKAGED DEVICES AND RELATED METHODS

TECHNICAL FIELD

[0001] The present invention generally relates to systems, apparatus and methods for testing packaged devices, microelectronic devices, micromechanical devices, and other devices with microfeatures.

BACKGROUND

[0002] Conventional packaged devices such as integrated circuit (IC) devices are painstakingly manufactured for specific performance characteristics required for use in a wide range of electronic equipment. IC devices typically include a die with electronic circuitry, a casing encapsulating the die, and an array of external contacts. IC devices have an outer shape that defines a package profile. The external contacts can be pin-like leads or ball-pads of a ball-grid array. The ball-pads are arranged in a selected pattern, and solder balls are connected to the ball-pads. Ball-grid arrays generally have solder balls arranged, for example, in 6x9, 6x10, 6x12, 6x15, 6x16, 8x12, 8x14, or 8x16 patterns on the IC device, but other patterns are also used. Many IC devices with different circuitry can have the same ball-grid array but different outer profiles.

[0003] After IC devices are packaged, they are generally tested and marked in several post-production batch processes. Burn-in testing is one such post-production process for detecting whether any of the IC devices are likely to fail. Burn-in testing is performed before shipping IC devices to customers or using IC devices in electronic equipment.

[0004] Burn-in testing of IC devices typically involves applying specified electrical biases and signals in a controlled temperature environment. The IC devices are

generally tested in more severe conditions and/or under more rigorous performance parameters than they are likely to experience during normal operation. During a typical burn-in test, several IC devices are loaded onto burn-in boards, and a batch of loaded burn-in boards is then placed in a test chamber (i.e., burn-in oven) that provides a controlled environment.

[0005] Burn-in boards are commonly printed circuit boards that conduct the electrical input/output parameters to the packaged devices. One example of a conventional burn-in board includes a printed circuit board and a plurality of sockets on the printed circuit board. The sockets each have a selected array of electrical leads electrically coupled to conductive lines in the printed circuit board. The electrical leads also have exposed contact tips positioned to engage solder balls of an IC device loaded into the socket. The conventional socket also has a nesting member with an opening that is shaped to closely correspond to the outer profile or shape of the IC device. The conventional nesting member receives the IC device and controls the position of the IC device within the socket in three dimensions (e.g., X, Y and Z axes). Accordingly, the nesting member ensures precise placement of the IC device in the socket so that the solder balls contact the correct electrical leads without damaging the solder balls. Precise and repeatable positioning of the IC devices in the sockets is essential for accurate and efficient burn-in testing of the IC device.

[0006] One problem with conventional burn-in boards is that it is difficult to perform burn-in tests for runs of IC devices with different profiles. In conventional systems, each socket typically has a dedicated nesting member configured to be used with IC devices with the same outer profile. The dedicated nesting member is accordingly used throughout several burn-in tests for IC devices with identical profiles. However, to test IC devices with different profiles on the same burn-in board requires reconfiguring all of the sockets to accommodate the different outer profiles. The sockets are reconfigured by removing the nesting members shaped for the outer profile of one type of IC device from each socket and attaching different nesting members specifically shaped and sized for the outer profile of another type of IC device. In a typical large scale manufacturing process for IC

devices, reconfiguring burn-in boards to test IC devices having a different outer profile usually involves reconfiguring thousands of sockets. This process is extremely labor intensive, time consuming, and expensive because it not only requires thousands of new nests and many hours of skilled labor, but it also results in costly down time for the burn-in boards and testing equipment. Moreover, the nesting members and the sockets can also be damaged during the process of changing the nesting members. Therefore, conventional systems are not well suited for performing burn-in tests on IC devices with different profiles.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0007] Figure 1 is an isometric view of a testing system for testing packaged devices in accordance with one embodiment of the invention.
- [0008] Figure 2 is an enlarged bottom isometric view of one packaged device of the type testable by the testing system of Figure 1.
- [0009] Figure 3 is an enlarged side elevation view of a socket on a burn-in board in the testing system of Figure 1.
- [0010] Figure 4 is a top plan view of the socket of Figure 2.
- [0011] Figure 5 is a top isometric view of a guide positionable in the socket of Figure 4.
- [0012] Figure 6 is a top plan view of the guide of Figure 5 shown installed in the socket of Figure 4.
- [0013] Figure 7 is an enlarged top plan view of the packaged device shown installed in the socket of Figure 4 and positioned on the guide of Figure 5.
- [0014] Figure 8 is an enlarged cross-sectional view taken substantially along line 8-8 of Figure 7 showing a portion of the packaged device in the socket and on the guide.
- [0015] Figure 9 is an enlarged partial plan view of the socket and the guide of Figure 6 positioned adjacent to an array of electric leads in the socket.
- [0016] Figure 10 is an enlarged bottom isometric view of a package handling assembly with a placement head under one configuration of the testing system of Figure 1.

[0017] Figure 11 is an enlarged side elevation view of the placement head of Figure 10 shown spaced above the socket of Figure 3.

[0018] Figure 12 is an enlarged side elevation view of the placement head positioned in engagement with the socket of Figure 3.

[0019] Figure 13 is an isometric view of an alternate embodiment of a placement head shown removed from the package handling assembly of Figure 1.

DETAILED DESCRIPTION

A. Overview

[0020] The following disclosure describes several embodiments for systems and apparatus for testing packaged devices, such as microelectronic devices, micromechanical devices, or other devices with microfeature components. Many specific details of the invention are described below with reference to a burn-in board with a plurality of sockets for testing the packaged devices, but embodiments can be used in other testing systems in the manufacturing of packaged devices. Several embodiments in accordance with the invention are set forth in Figures 1-13 and in the following text to provide a thorough understanding of particular embodiments of the invention. A person skilled in the art will understand, however, that the invention may have additional embodiments, or that the invention may be practiced without several of the details of the embodiments shown in Figures 1-13.

[0021] One aspect of the invention is directed to testing systems for testing a packaged device having a body with a package profile and an array of contacts coupled to the body. In one embodiment, the system includes a socket connectable to a testing substrate. The socket has an array of leads arranged to engage the array of contacts on the packaged device. The socket has a receiving area proximate to the array of leads and configured to receive the packaged device therein.

[0022] The system of this embodiment also has a package handling assembly with a placement head and an alignment element coupled to the placement head. The

alignment element is movable with the placement head as a unit relative to the socket to be positioned at the receiving area of the socket. The alignment element has an alignment portion configured to receive the packaged device and restrict movement of the packaged device in at least two dimensions relative to the array of leads as the packaged device passes through the alignment portion. The alignment portion accordingly positions the packaged device in the receiving area adjacent to the array of leads.

[0023] Another aspect of the invention is directed to methods of testing a packaged device having an array of contacts and a package profile. In one embodiment, the method includes moving a packaged device along a load/unload path through an alignment element that restricts movement of the package laterally with respect to the load/unload path. For example, the alignment element is positioned in a socket and then a packaged device passes through an aperture in the alignment element that guides the packaged device in a manner so that the contacts are aligned with corresponding leads in the socket. The packaged device is placed against the socket with the array of contacts contacting the array of leads. The alignment element is then removed from the socket without removing the packaged device, and the packaged device is tested in the socket. The alignment element is accordingly separate from the socket.

[0024] A feature of several testing systems in accordance with certain embodiments of the invention is that the testing system can be reconfigured to test packaged devices having different profiles. For example, a testing system can have a socket with a lead array and a handling assembly having a placement head with a first alignment element. The first alignment element has a first aperture having first guide portions configured to align a first package having a first profile with the lead array. The placement head moves between a first position at which the first aperture is proximate the lead array and a second position at which the alignment element is spaced apart from the socket. After loading a plurality of first packaged devices onto sockets through the first alignment array, second packaged devices with different profiles can be loaded onto the sockets without necessarily reconfiguring the sockets by (a) removing the first alignment element

from the placement head, (b) attaching a second alignment element to the placement head, (c) moving the second alignment element between the first and second positions, and (d) passing individual second packaged devices through the second alignment element when the second alignment element is in the first position proximate the socket. The second alignment element has a second aperture with second guide portions configured to align the second packaged devices with the lead arrays.

B. Testing Systems

[0025] Figure 1 is an isometric view of a testing system 10 for testing a plurality of packaged devices 12 in accordance with an embodiment of the invention. In this disclosure the term "packaged device" includes micromechanical devices, microelectronic devices, and other devices with microfeature components. In the illustrated embodiment, the testing system 10 is configured for burn-in testing of packaged devices 12 to verify and ensure that the packaged devices function according to specification.

[0026] The testing system 10 includes a bed 14 that removably receives a tray 16. The tray 16 includes a burn-in board 18 having a plurality of sockets 20 operatively mounted on a printed circuit board 22. In the illustrated embodiment, the burn-in board 18 includes a 16x16 array of substantially identical sockets 20. The burn-in board 18, however, is not limited to having a 16x16 array of sockets and can have other socket configurations.

[0027] The testing system 10 also includes a package handling system 24 over the burn-in board 18. The package handling assembly 24 includes a row of placement heads 26 mounted on an elongated support bar 28. The placement heads 26 are positioned on the support bar 28 so that each placement head is aligned with a respective one of the sockets 20 in a row of sockets on the burn-in board 18. The package handling assembly 24 also includes a vacuum pick-and-place system 29 (shown schematically) that transports individual packaged devices 12 to and from individual placement heads 26 and sockets 20. In operation, the elongated support bar 28 moves downwardly to position each placement head 26 at a corresponding socket 20.

[0028] The pick-and-place system 29 in one embodiment has two sets of pick-and-place heads (not shown), and each set includes sixteen pick-and-place heads. Each pick-and-place head includes a pick up member that has a partial vacuum being drawn through an interior channel. The pick-and-place heads use the partial vacuum to pick up a packaged device 12 from a selected area, and then the pick-and-place heads transport the packaged devices 12 to the placement heads 26. As the pick-and-place heads are picking up the packaged devices 12 and moving toward the placement heads 26, the placement heads are positioned in a row of sockets 20, as discussed in greater detail below. The pick-and-place heads pass the packaged devices 12 through the placement heads 26 and into the sockets 20. The placement heads 26 align the packaged devices 12 with the sockets 20 also discussed in greater detail below, so the packaged devices 12 can be quickly and precisely loaded into the sockets 20.

[0029] The pick-and-place heads position the packaged devices 12 within placement heads 26 so the packaged devices are each spaced slightly apart from the testing sockets 20 by a small gap (e.g., by approximately 1 mm). The vacuum in each pick-and-place head is then terminated, so the packaged device 12 precisely drops into position on the testing socket 20. In one embodiment, the packaged device 12 can be separated from the pick-and-place head by blowing a puff of air through the pick-up member, thereby blowing the packaged device off of the pick-and-place head. The packaged device 12 then drop across the small gap and into precise position on the testing socket 20.

[0030] After the packaged devices 12 are loaded into the row of the testing sockets 20, the first set of pick-and-place heads are lifted out of the placement heads 26. The support bar 28 and placement heads 26 are then raised to a position above the testing sockets 20. The bed 14 of the testing system 10 moves the burn-in board 18 so as to index the next row of testing sockets 20 below the row of placement heads 26. The support bar 28 is then lowered and the placement heads 26 are positioned in the row of testing sockets 20. In one embodiment, the second set of pick-and-place heads are loaded with packaged devices 12 while the first set of pick-and-place heads is delivering its sixteen packaged devices, as

discussed above. The loaded second set of pick-and-place heads is then moved into positioned in the placement heads 26 in the same manner discussed above to deliver the packaged devices into the next row of testing sockets. While the second set of pick-and-place heads is delivering the packaged devices 12, the first set of pick-and-place heads are loaded with other packaged devices to be delivered in the next row of testing sockets 20. The first and second sets of pick-and-place heads alternate in loading rows of the testing sockets 20 until the burn-in board 18 is loaded.

[0031] In alternate embodiments, other arrangements of pick-and-place heads can be used to load the packaged devices 12 into the placement heads 26 and into the testing sockets 20. For example, a single set of pick-and-place heads can be used to load each row of sockets 20. In another embodiment, a single pick-and-place head could be used to load each socket 20. In another embodiment, the placement heads 26 can be coupled directly to the pick-and-place heads so as to move together when the packaged devices 12 are picked up and delivered to the testing sockets 20.

[0032] Figure 2 is an enlarged bottom isometric view of a conventional packaged device 12 that contains internal circuitry 32 (shown schematically). The illustrated packaged device 12 has a profile 38 defined by the perimeter edge of the top or bottom surface. The profile 38 of the packaged device 12 can be different than the embodiment shown in Figure 2. The internal circuitry 32 is operatively connected to a plurality of electrically conductive ball-pads that carry solder balls 34 arranged in a ball-grid array 36. In the illustrated embodiment, the ball-grid array 36 is a 6x10 array, but the packaged device 12 can have different ball-grid arrays.

[0033] Figure 3 is an enlarged side elevation view of one of the sockets 20 of Figure 1, and Figure 4 is a top plan view of the socket 20 of Figure 3. The socket 20 of the illustrated embodiment includes a base 40 and a lead array having a plurality of electrically conductive leads 42 connected to circuitry 44 in the printed circuit board 22 (Figure 3). The leads 42 extend upwardly through the base 40 and protrude through apertures 46 (Figure 4) formed in a slider 48 movably mounted to the base 40. The leads 42 can be arranged in an array that

corresponds to the ball-grid array 36 on a packaged device 12 (shown in phantom lines) that is to be tested in the socket 20. The array of leads 42 is configured to removably connect individual leads 42 to individual solder balls of the ball-grid array 36 when the packaged device 12 is properly positioned in the socket 20.

[0034] The socket 20 includes a spring-loaded cover 50 movably connected to the base 40 to define a receiving area 52 relative to the slider 48 and the array of leads 42. The receiving area 52 in the socket 20 is shaped and sized to removably receive a portion of the placement head 26 (Figure 1) as a packaged device is loaded into the socket 20. As explained below, the same socket 20 can be used to test a plurality of different packaged devices having the same ball-grid array configuration but different profiles. The sockets 20 are accordingly substantially independent of the package profiles.

[0035] The socket 20 shown in Figures 3 and 4 does not have a conventional nest in the receiving area 52. As explained above in the background section, a conventional nest holds the packaged device in the socket in a manner that protects the solder balls from being damaged and aligns the solder balls with corresponding leads of the socket. The testing system 10 shown in Figure 1 protects the solder balls and aligns the solder balls with the leads without a nest by (a) providing a guide that protects the solder balls of packaged devices irrespective of the package profile and (b) aligning the solder balls with leads using the placement heads 26 (Figure 1). Figures 5-9 describe several embodiments of the guides that are removably attachable to the sockets 20 for protecting the solder balls from being damaged as they contact the leads 42 (Figure 45). Figures 10-13 then describe several embodiments of placement heads that align the packaged devices with the sockets 20 so that the solder balls contact the correct leads.

[0036] The solder balls in the ball-grid array 36 are very fragile and must be precisely placed in the socket 20 relative to the slider 48 and the array of leads 42 to avoid damaging the packaged device 12. Figure 5 is a top isometric view of a guide 56, and Figure 6 is a top plan view of the socket 20 with the guide 56 positioned within the receiving area 52 adjacent to the slider 48. The guide 56 of

the illustrated embodiment is configured to position and support the packaged device 12 at a selected position away from the slider 48 (Figure 6). In one embodiment, the guide 56 is removably connected to the socket 20 (Figure 6), and in other embodiments the guide may be integrally connected to the socket. The guide 56 provides a surface plane to register the packaged device 12 relative to the leads 42.

[0037] The guide 56 of the illustrated embodiment is a generally planar member having a central aperture 58 shaped and sized to extend around the array of leads 42 (Figure 6). The aperture 58 is also shaped and sized to receive the ball-grid array 36 (Figure 2) when the packaged device 12 is positioned in the socket 20. In one embodiment, the aperture 58 is shaped to closely correspond to the outline of the ball-grid array. Accordingly, the guide 56 and the corresponding socket 20 are keyed to the ball-grid array rather than being keyed to the package profile of the packaged device. The guide 56 also has projections 68 projecting upwardly from the top surface. The projections 68 are arranged to support the packaged device in a specific plane relative to the socket 20 when the guide 56 is attached to the socket 20. Additional aspects of the projections are described below regarding Figure 8.

[0038] As best seen in Figure 5 and 6, the guide 56 of the illustrated embodiment includes a plurality of retention members 60 that removably retain the guide in the receiving area 52 of the socket 20 at a desired position relative to the array of leads 42. The retention members 60 of the illustrated embodiment have hook portions 62 (Figure 5) that engage the base 40 and securely retain the guide 56 in a fixed position relative to the base. The retention members 60 are configured so the slider 48 can translate laterally (i.e., left-right in Figure 6) relative to the base 40 and the leads 42 when the spring-loaded cover 50 is depressed relative to the base 40. While the illustrated embodiment has retention members 60 with hook portions 62, other embodiments can use other retention devices that removably retain the guide 56 in the receiving area 52. Accordingly, the guide 56 can be removed and replaced in the event a guide is damaged or if the socket 20 is to be

used for testing packaged devices with different ball-grid arrays that require a different shaped or sized guide 56.

[0039] Figure 7 is a top plan view of the socket 20 with the packaged device 12 positioned in the receiving area 52 (Figure 6) and supported above the array of leads 42 (Figure 6) by the guide 56. As best seen in Figure 7, the package profile 38 of the packaged device 12 is spaced apart from the outermost edges of the guide 56 and the slider 48 when the packaged device is positioned within the receiving area 52. The same socket 20 and guide 56 can be used to removably retain a plurality of different packaged devices with substantially identical ball-grid arrays 36 but different profiles. The leads 42 can also be part of a universal array that can be selectively configured to work with different ball-grid arrays. The socket 20 and guide 56 are very versatile such that the same burn-in board 18 (Figure 1) can be used to burn-in a plurality of different packaged devices 12 without having to reconfigure each of the 256 sockets on the burn-in board when the profile of the packaged devices changes.

[0040] Figure 8 is an enlarged cross-sectional view taken substantially along line 8-8 of Figure 7 showing a portion of the packaged device 12 in the socket 20 and supported on the guide 56. The guide 56 of the illustrated embodiment extends under an edge portion 70 of the packaged device 12. The projections 68 of the guide 56 of the illustrated embodiment contact the packaged device 12 at discrete points to support the packaged device 12 in a reference plane 66 (in Figure 8) spaced apart from the leads 42. The top surfaces of the projections 68 together define the reference plane 66, and they are positioned to support edge portions 70 of the packaged device 12. The projections 68 can be any of a variety of shapes, including, as only a few examples, rectangular, triangular, or partial spherical.

[0041] The projections 68 of the illustrated embodiment are the only parts of the guide 56 that physically touch the packaged device 12. Accordingly, surface defects that may occur on the guide 56 or the packaged devices 12 during manufacturing are less likely to negatively impact the ability of the guide 56 to properly position the packaged device 12 at the desired distance above the leads 42. In addition, the guide 56 with the projections 68 has the added benefit of

allowing any overall bow in the packaged device 12 to be less critical or sensitive in terms of affecting where the leads 42 reference the solder balls along the Z-axis.

[0042] While the illustrated embodiment includes a guide 56 as a separate and removable structure from the socket 12, other embodiments can include a guide 56 integrally formed with the slider 48 adjacent to the array of electric leads. The integrally formed guide 56 is carefully sized for selected packaged devices 12 so that the ball-grid arrays 36 are properly positioned relative to the leads 42. Accordingly, the guide need not be separate from the socket. In another embodiment, the guide 56 can be formed partially on the packaged device 12 and partially on the base 40 of the socket 20. In yet another embodiment, the guide 56 is integrally formed solely on the packaged device 12. In this alternate embodiment, the guide 56 supports the packaged device 12 at the desired distance from the slider 48 when in the socket 20, but the guide is also configured so it does not interfere with the mounting of the packaged device on an end product, such as a printed circuit board for an electronic device.

[0043] In some instances during burn-in testing of the packaged devices 12, the heat and/or other conditions of the test may result in some of the solder balls 34 sticking to the leads 42 or to a portion of the slider 48. As a result, the packaged device 12 can be accidentally damaged during removal from the socket 20.

[0044] Figure 9 is an enlarged partial top plan view of the slider 48 and a portion of the guide 56 adjacent to the array of leads 42. The guide 56 includes a plurality of anti-stick members 72 positioned to engage the packaged device 12 to detach the solder balls 34 (Figure 8) from the leads 42 before the packaged device is removed from the socket 20. The anti-stick members 72 of the illustrated embodiment are projections that extend laterally toward the leads 42, generally parallel to the top surface of the slider 48. Accordingly, as the slider 48 moves laterally relative to the anti-stick members 72 during the process of removing the packaged device 12 (Figure 8) from the socket 20, the anti-stick members 72 prevent the packaged device 12 (Figure 8) from translating laterally with the slider 38. The leads 42 can accordingly move apart fully disengage the solder balls 34

(Figure 8). The packaged device 12 can then be lifted from the socket 20 without damaging the ball-grid array 36.

[0045] As indicated above, the guide 56 of the illustrated embodiment aligns the packaged device 12 in a selected position along one axis (i.e., the Z-axis) relative to the leads 42 when the packaged device 12 is loaded into the socket 20. The socket 20 of this illustrated embodiment, however, does not have a nest to align the packaged device 12 along the X-axis and Y-axis relative to the leads 42. Alignment along the X-axis and Y-axis is accomplished by the package handling assembly 24 as shown in Figures 10-13.

[0046] Figure 10 is an enlarged bottom isometric view of an embodiment of a portion of the package handling assembly 24 of Figure 1 with the placement head 26 mounted on the support bar 28. Figure 11 is a side elevation view of an alternate embodiment of the placement head 26 spaced above the socket 20. Figure 12 is a side elevation view of the placement head 26 pressed into engagement with the socket 20. The placement head 26 is configured to direct the packaged device 12 (shown in phantom lines) into and out of the socket 20 (Figures 11 and 12) while maintaining the required alignment of the packaged device along the X-axis and Y-axis relative to the socket 20.

[0047] Referring primarily to Figure 10, the placement head 26 of the illustrated embodiment includes a fixture 74 removably connected to the elongated support bar 28 proximate to an enlarged aperture 76 in the support bar 28. The fixture 74 also has an aperture 78 aligned with the aperture 76 in the support bar 28. The apertures 76 and 78 are shaped and sized to allow, as one example, a portion of the vacuum pick-and-place system 29 (Figure 1) and a packaged device 12 to pass through the support bar 28.

[0048] The placement head 26 includes an alignment element 80 movably connected to the fixture 74 and axially aligned with the apertures 76 and 78. In the illustrated embodiment, the alignment element 80 is connected to springs 82 that allow the alignment element 80 to move axially relative to the fixture 74. The alignment element 80 fits into the receiving area 52 (Figure 4) in the socket 20 (Figure 4) to provide precise placement of the alignment element 80 relative to the

array of leads 42 (Figure 4) when a packaged device 12 is being loaded into the socket. For example, the alignment element 80 includes outer guide surfaces 88 that nest with the cover 50 of the socket 20 when the alignment element 80 is positioned in the receiving area 52. The outer guide surfaces 88 accurately position the alignment element 80 within the socket 20 laterally (i.e., along the X-axis and Y-axis) relative to the guide 56 (Figure 6) and the array of electrical leads 42. The alignment element 80 can have a substantially flat bottom surface 84 that fits into the receiving area 52 in the test socket 20 and presses against the guide 56 (Figure 6) when the packaged device 12 is being inserted into the socket. The alignment element 80 of the illustrated embodiment is a generally rectangular member with a flat bottom surface, but the alignment element can have other shapes and configurations that still provide the relative alignment along the X-axis and Y-axis in other embodiments.

[0049] The alignment element 80 of the illustrated embodiment also includes interior guide surface 90 specifically positioned and sized to correspond to the package profile 38 of the packaged device 12. The interior guide surfaces 90 are configured to receive a packaged device 12 and accurately retain the packaged device in a selected position along the X-axis and Y-axis relative to the array of leads 42 in the socket 20. The interior guide surfaces 90 align the packaged device 12 such that, when the packaged device is separated from the pick-and-place head and drops across the small gap (as discussed above) onto the guide 56 in the testing socket, the packaged device remains precisely aligned along the X-axis and Y-axis. In the illustrated embodiment, the interior guide surfaces 90 include beveled portions that are inclined inwardly and downwardly to provide a wider opening in the alignment element adjacent to the fixture 74 and a narrower opening 92 at the bottom surface 84 to align a packaged device 12 as it moves downwardly through the alignment element. Accordingly, the alignment element 80 positions the packaged device 12 in the X-axis and Y-axis for proper positioning of the ball-grid array (Figure 2) in direct alignment with the leads 42.

[0050] In the embodiment illustrated in Figure 10, the springs 82 urge the alignment element 80 away from the fixture 74. When the alignment element 80 is

pressed into engagement with the guide 56 in the socket 20 (Figure 6), the springs 82 are compressed and bias the alignment element against the guide 56. As the placement head 26 starts to lift away from the testing socket 20, the springs 82 keep the alignment element 80 in engagement with the guide 56 until the springs return to their uncompressed position. Also, as the placement head 26 starts to lift away from the testing socket 20, the fixture 74 lifts relative to the guide 56 and causes clamp members in the testing socket to engage and hold the packaged device 12 in place against the guide 56. Accordingly, the biased alignment element 80 keeps the packaged device 12 in alignment in the testing socket 20 until the clamps in the testing socket 20 can secure the packaged device 12 in place, thereby preventing the packaged device's ball grid array 36 from being knocked out engagement with the leads 42 (Figure 8). The placement head 26 is configured so that, after the clamps in the socket 20 have secured the packaged device 12 with the socket 20, the alignment element 80 is lifted with the fixture 74 away from the testing socket leaving the packaged device precisely aligned in the socket.

[0051] In an alternate embodiment shown in Figure 11, the fixture 74 and the alignment element 80 are rigidly connected together. In this embodiment, the alignment element 80 is lifted away from the guide 56 (Figure 6) at the same time the fixture 74 is lifted from the testing socket 20. As the alignment element 80 is lifted from the guide 56, the clamps in the testing socket simultaneously secure the packaged device 12 in place to prevent the ball grid array 36 from being knocked out of engagement with the leads 42 in the testing socket 20.

[0052] The package handling assembly 24 can be set up with an array of placement heads 26 having alignment elements 80 configured for a selected package profile 38 (shown in phantom). The package handling assembly 24 can then be used to accurately place the packaged devices 12 in precise positions relative to the X-axis and Y-axis into the sockets 20. After the packaged device 12 is properly loaded in the socket 20, the alignment element 80 is removed from the socket 20 so that when the package handling assembly 24 lifts the placement

heads 26 away from the sockets. The loaded packaged device 12 is left in position in the socket 20 and ready for the burn-in testing.

[0053] After the alignment element 80 is removed, the area around the packaged device 12 is fairly open and allows for air flow around the packaged device, particularly during the burn-in testing. The airflow around the packaged device 12 provides improved thermal impedance and heat transfer away from the packaged device and the test socket 20. The airflow also results in reduced heat gradients between the packaged device 12 and primary air streams provided in a conventional burn-in oven.

[0054] In the event that the package handling assembly 24 needs to be reconfigured to handle packaged devices 12 with a different package profile 38, the placement heads 24 can be easily removed and replaced by new placement heads with alignment elements 80 shaped and sized for the selected package profile. In an alternate embodiment, the placement heads 26 can be reconfigured to remove and replace the alignment elements 80 with other alignment elements configured for the selected package profile. Once the placement heads 26 or alignment elements 80 are reconfigured, the new placement heads 26 can be used with the same 256 sockets 20 on the burn-in board 18 without having to reconfigure each and every one of those sockets. As a result, the burn-in testing of packaged devices 12 with common ball-grid arrays 36 but different package profiles can be accomplished much more efficiently.

[0055] Figure 13 is an enlarged isometric view of an alternate embodiment of the placement head 26 and alignment element 80. In this alternate embodiment, the alignment element 80 is movably coupled to the fixture 74 by a pair of spring arms 92. The spring arms 92 allow the alignment element 80 to move axially relative to the aperture 78 in the fixture 74 when the alignment element is pressed into engagement with the socket 20 (Figure 3). The spring arms 92 are connected to the alignment element 80 and to the fixture 74 by conventional fasteners 94 so the alignment head can be easily removed and replaced.

[0056] From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various

modifications may be made without deviating from the spirit and scope of the invention. For example, the placement head 26 of the illustrated embodiments is shown mounted on an automated package handling assembly 24. In an alternate embodiment, the placement head 26 can be installed on a hand tool used for individually placing selected packaged devices 12 in sockets 20 for selected tests or analysis. Accordingly, the invention is not limited except as by the appended claims.